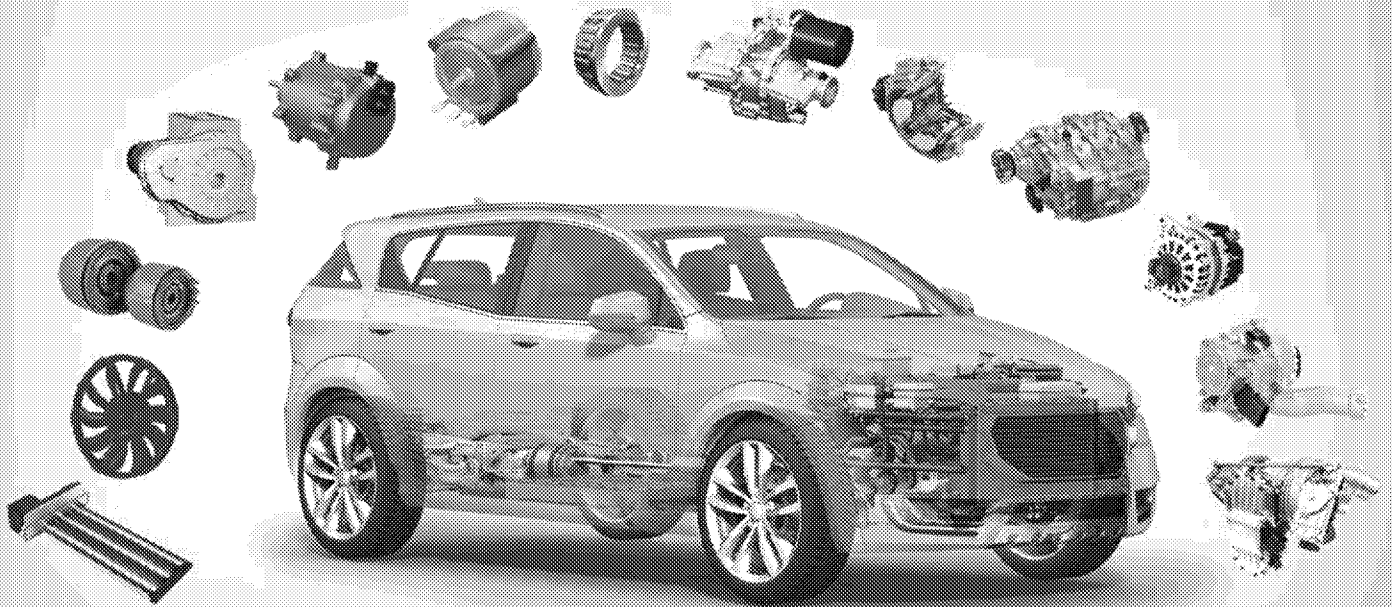




48V Propulsion Technologies



Securing an edge through system expertise.
Explore our 48 volt technologies for more
efficient vehicle generation.



With the conviction that 48V systems are a central technology for advanced vehicles, we have currently developed one of the broadest 48V portfolios in the industry. Many of our innovative solutions are already available today or are in development ready for serial production. Our wide range of expertise in the fields of electric motors, power electronics, and mechanical components as well as our comprehensive system expertise in the propulsion solutions put us in a unique position. This makes us the leading manufacturer of propulsion technologies for vehicles with combustion engines as well as hybrid and electric vehicles.

One system, many benefits.

Modern vehicles are consuming increased electricity, which calls for a high-performance on-board power supply system. The 48V boardnet delivers sufficient power and offers a wide range of options for optimizing propulsion in terms of fuel economy, emissions, and dynamic driving

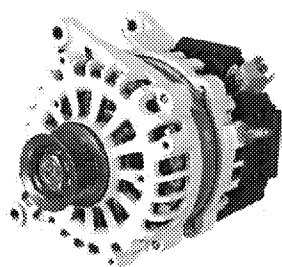
performance. It can be implemented economically while at the same time being powerful.

BorgWarner has a large number of 48 volt technologies in its portfolio, each offering significant efficiency gains. Further benefits include simple integration, lower weight, and reduced space requirements, which permit more flexible usage of the installation area. As highlighted during both the preliminary development and series development phases, fuel savings of up to 20% can be achieved with corresponding improvement of the exhaust emission values in real-world driving conditions. Our solutions can also optimize passenger comfort through improved response or better power transmission. With our diverse product portfolio and comprehensive system expertise, we are capable of developing this potential for our customers. Many of our 48 volt technologies are already proving their value today in the production cars of leading vehicle manufacturers.

Alternator / Starter

Integrated Belt Alternator Starter (iBAS)

By shutting the engine off when the vehicle stops, stop/start systems increase fuel economy 3% to 10%, depending on the system application and driving patterns. BorgWarner's belt alternator starter (iBAS) features integrated power electronics to deliver fast, quiet engine restarts, high-efficiency energy generation, engine torque assist and regenerative braking. Our iBAS can replace conventional and start stops starters due to its high torque capability.



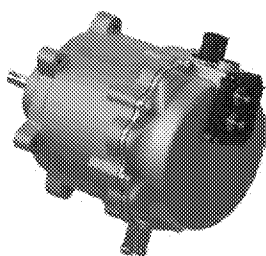
FEATURES AND BENEFITS

- ※ Improves fuel economy with quiet engine starts
- ※ Integrated power electronics
- ※ Supports regenerative braking
- ※ High-efficiency power generation for energy storage, torque assist and accessory loads

Motors / Generators

Our motor/generators considerably reduce the cost of electrification when compared to high voltage hybridization and pure EV. The 48 volt technology provides higher system efficiency and improved energy recovery capability to meet increasing power demands.

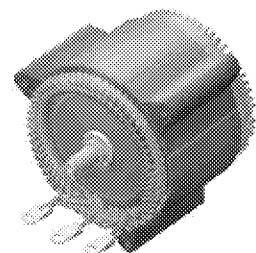
Motor Generator With Integrated Electronics (MGI)



FEATURES AND BENEFITS

- ※ 4-quadrant motor drive
- ※ Operates at temperatures up to 125°C
- ※ Liquid cooled
- ※ 18,000 rpm max rotor speed
- ※ CAN or LIN communication
- ※ Direct drive, chain drive, belt drive, or integrated options
- ※ Multiple electromagnetic variants to meet varying performance requirements

High Torque Motor Generator Unit



FEATURES AND BENEFITS

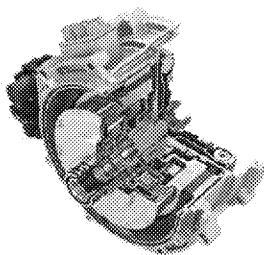
- ※ Full motoring & generating capability
- ※ Internal permanent magnet rotor
- ※ Operates in ambient up to 125°C ambient
- ※ Oil cooled (WEG optional)
- ※ 7,000 rpm max rotor speed
- ※ 94 % peak efficiency
- ※ Direct drive, chain drive, belt drive, or integrated options possible

Hybrid Modules

In order to support the transition to cleaner and more efficient vehicles, BorgWarner offers its P2 module for hybrid electric vehicles (HEVs). The company's highly flexible technology facilitates fast-to-market hybridization by enabling pure electric driving as well as hybrid functionalities such as stop/start, regenerative braking and supplemental electric propulsion. By uniting all required components in a compact package, BorgWarner's advanced solution can easily be implemented in existing drivetrains, enabling high degrees of existing capital utilization and hybrid volume flexibility for automakers. Furthermore, both configurations of the company's P2 module provide significant CO₂ emission reductions with low added costs compared to other hybrid architectures.

P2 On-Axis Hybrid Module

BorgWarner's P2 module converts a combustion-powered vehicle into a hybrid without changing the engine or transmission. That means automakers can easily expand their vehicle portfolio with less investment and more flexibility. Placed between the engine and transmission, the highly efficient P2 module combines a 48V electric traction motor, engine disconnect clutch, launch device and dual mass flywheel into a compact package nested inside the motor.

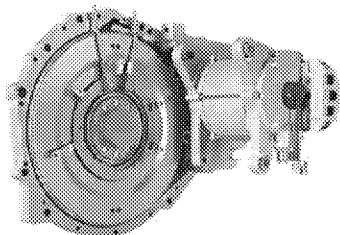


FEATURES AND BENEFITS

- ✦ Compatible with all transmission architectures, including manual transmissions
- ✦ Compact design with up to three nested clutches minimizes overall length
- ✦ Clutch hydraulic control module available
- ✦ Efficient oil and water-cooled traction motor
- ✦ High-performance, low-noise stator offers 95 % peak efficiency
- ✦ Integrated engine disconnect clutch
- ✦ May also include integrated dual-mass flywheel and launch device
- ✦ S-winding technology improves power density

P2 Off-Axis Hybrid Module

The off-axis configuration places the electric motor parallel to the main axis for an even more compact axial package, minimizing changes necessary to implement with existing engines and transmissions. Torque is transferred via a highly efficient and durable chain. This design offers compatibility with manual, automatic and dual-clutch transmissions and addresses the tight packaging of modern drivetrains.

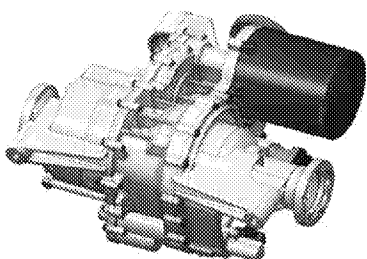


FEATURES AND BENEFITS

- ✦ Less axial length increase as compared to P2 on-axis
- ✦ Hy-Vo® silent chain transfers power with best-in-class efficiency and NVH
- ✦ Self contained wet enclosure
- ✦ Replaces starter; can also drive AC pump

eRDM (Rear Drive Module) with Torque Vectoring

Torque vectoring goes electric with BorgWarner's eRDM, which combines torque vectoring with full-function mechanical AWD for maximum vehicle stability. Front wheel drive vehicles can be transformed to AWD with the company's latest AWD coupling with integrated, electric actuators.

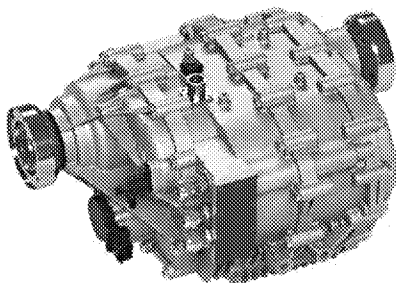


FEATURES AND BENEFITS

- ✦ Improved fuel economy through 48V hybridization
- ✦ Torque vectoring
- ✦ Regeneration - recuperation of kinetic energy during coasting and braking
- ✦ Boosting during launch and acceleration
- ✦ Sailing at low speeds
- ✦ Shift between hybrid, neutral and torque vectoring modes

eAWD

eAWD is an innovative rear axle drive concept for hybrid and pure electrical vehicles, with optional torque vectoring to improve stability and vehicle dynamics.

**FEATURES AND BENEFITS**

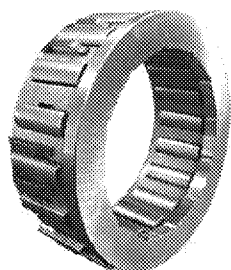
- ✧ Optional 1 or 2-Speed function for enhanced AWD and regen
- ✧ Launch assist (engine downsizing enabler) and creep capable for extended S/S
- ✧ Integrated motor provides full power over a large rpm range
- ✧ In-house power electronics
- ✧ Improved traction management through expert AWD insight
- ✧ 1,500 Nm launch torque

Transmission Technologies

BorgWarner's 48 volt transmission technologies deliver improvements in drivetrain efficiency. Offered in a variety of applications, our products help to improve fuel efficiency, acceleration, traction management and overall vehicle performance.

SiEVT One-Way Clutch

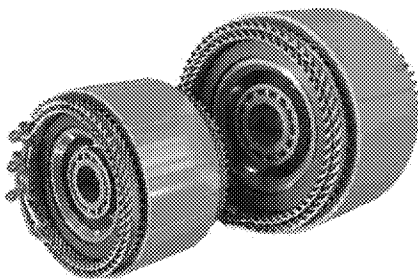
The SiEVT One-Way Clutch is an innovative technology which helps to improve the efficiency of a 48 volt system. When a gasoline engine powers a vehicle, the one-way clutch spins freely, allowing the secondary motor to generate electricity for improved battery and fuel efficiency. During all-electric operation, BorgWarner's one-way clutch enables both the traction-drive motor and secondary motor to generate torque for improved acceleration and performance.

**FEATURES AND BENEFITS**

- ✧ Dual cage phasing design
- ✧ Low dynamic friction coated end bearing for concentricity control
- ✧ High torque capacity/small package
- ✧ High speed/log drag design

Power Split Hybrid

The Power Split Hybrid is an innovative solution which integrates a motor and generator into a vehicle's transmission. With engine stop/start and regenerative braking potential, the Power Split Hybrid allows for drastic increases in fuel efficiency.

**FEATURES AND BENEFITS**

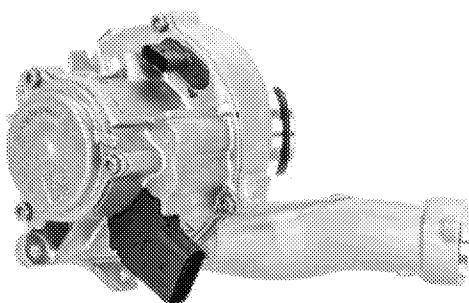
- ✧ Best electric motor portfolio in technology and variety offered
- ✧ Integrated S-winding technology
- ✧ Improved copper filling factors leading to higher efficiency
- ✧ High scalability and various stack length options
 - Load point raising
 - Engine Stop/Start
 - Engine Off Sailing
 - 20 - 25 % Fuel Efficiency Gain

Electric Boosting Technologies

BorgWarner turbochargers have been renowned for their exceptional efficiency for decades. Our electrically operated eBooster® and eTurbo™ turbocharging systems facilitate further significant improvements for the internal combustion engine in terms of fuel economy, emissions, and power delivery. Designed as powerful booster compressors in the 48V on-board power supply system, they improve both dynamic performance and fuel efficiency, particularly at low engine speeds.

eBooster® – electrically driven compressor

The eBooster® is an electrically assisted booster system. It uses a flow compressor driven by an electric motor, which is fitted as a component either upstream or downstream of the turbocharger. The high levels of boost offered by the eBooster® allow small and economical engines to be developed with dynamic performance comparable to that of large, normally-aspirated engines delivering the same power – while significantly reducing both consumption and exhaust emission values.



TECHNICAL FEATURES

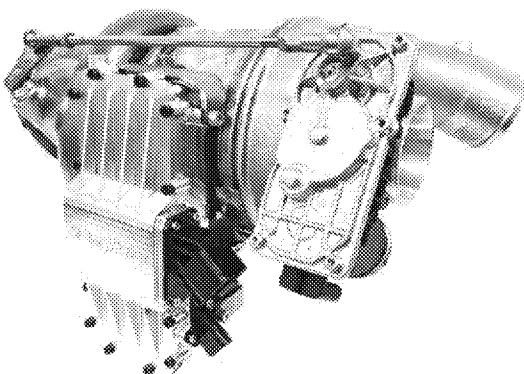
- ✱ Compact design, integrated power electronics
- ✱ Bearing technology life lubricated (ball bearing)
- ✱ 12V/48V product range
- ✱ Solution for Diesel & Gasoline

SYSTEM BENEFITS

- ✱ Enhanced transient boost response
- ✱ Reduced emission level
- ✱ Fuel consumption reduction
- ✱ Enabler for further downsizing

eTurbo™

The eTurbo™ is a turbocharger with integrated electric motor that serves as both a drive and an alternator. The electric motor supports the compressor in building up boost pressure, particularly at low speeds, and thereby improves response. In its role as an alternator, the electric motor then extracts energy from the exhaust gas stream. When electric support is deactivated, the eTurbo™ operates like a classic turbocharger. The system is primarily used to improve dynamic driving performance.



PRODUCT FEATURES & SPECIFICATIONS

- ✱ Modular 48V and high voltage version
- ✱ Integrated power electronics

VERSIONS AVAILABLE

- ✱ Up to 11 kW continuous power and 17 kW peak power
- ✱ Air cooled (optional water cooled)
- ✱ Integrated power electronics
- ✱ Controller (remote mount optional)

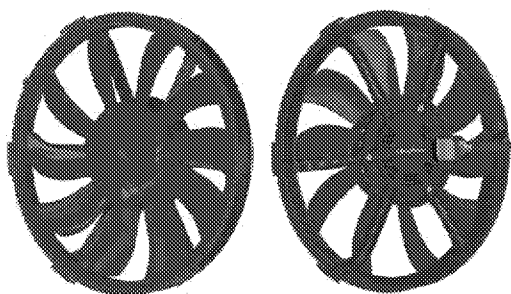
SYSTEM BENEFITS

- ✱ Single-machine solution for electrified boost assistance and recuperation
- ✱ Reduced turbo lag; better low rpm engine torque, faster time-to-torque
- ✱ Smaller engine or lower speed engine can be used and have acceptable levels of torque and response
- ✱ Fuel economy improves due to downsized or lower speed engine
- ✱ Wasted exhaust energy is converted to electrical energy

Thermal Management

eFan

The new 48V eFans from BorgWarner offer superior thermal management by delivering powerful and highly efficient airflow performance. The system's concept is based on a scalable brushless DC motor design with integrated electronics, providing fast fan speed responsiveness for precise temperature control and low noise in an optimized lightweight package. The product family's modular design allows a variety of flexible system arrangements at very competitive packaging requirements and low system weights.

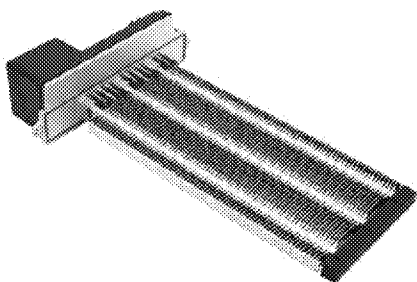


FEATURES AND BENEFITS

- ※ Extended Power range
 - Scalable 48V motor technology allows fan power of up to 3 kW
 - Enabled by high efficiency electronics and torque controlled motor
- ※ High Efficiency and Low Noise
 - High performance fan blades and high torque motor enable lower peak speeds
 - Various aerodynamic Features for noise reduction
- ※ Innovative integral motor concept with active cooling
 - Permits up to 120°C operating temperature
 - Long lifetime due to protection from contamination
- ※ Novel assembly concept
 - Allows efficient manufacturing processes
 - Function integration leads to low weight

Cabin Heater

BorgWarner's 48V PTC heater provides supplemental passenger heating in 48V hybrid applications, independent of engine operating temperature. Building on proven robust designs, this new 48V heater provides excellent levels of performance, efficiency and safety. By utilizing 48V PTC heaters in hybrid applications, customers can maximize the benefit the hybrid system can provide and avoid excessive combustion engine operation.



FEATURES AND BENEFITS

- ※ Safe design based on fully enclosed heater rods
- ※ Robust electronic design
- ※ Fully controllable power delivery
- ※ Low pressure drop
- ※ Odour free

VERSIONS AVAILABLE

- ※ Power range 1 - 2.5 kW depending on heater core package size
- ※ Electronic control or relay stepped heater
- ※ LIN, CAN or PWM controlled

Paving the way for a clean, energy-efficient world.

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